

1 **Abstract**

2 **Objective** Head injury is a common presentation to the emergency department yet adherence to
3 guidelines for management is suboptimal. Our study assesses adherence to National Institute for
4 Health and Care Excellence (NICE) computed tomography (CT) head guidelines at a teaching
5 hospital in the United Kingdom. It critically evaluates the efficacy of interventions.

6 **Methods** We performed a quality improvement project to improve adherence to NICE CT head scan
7 guidelines following head injury. Data was collected over one-month in 2014, and 2017. Interventions
8 included education of the multidisciplinary team, information sheets, team engagement and tri-annual
9 education sessions for junior doctors. The success of these interventions in the adult population was
10 assessed objectively during the second cycle and subjectively via a junior doctor survey.

11 **Results** 171 patients were included in the study. Following interventions, there was a statistically
12 significant decrease of 23% in the number of CT heads requested with no clear indication
13 ($P=0.00027$). The mean time to scan for the one-hour indications decreased from 73 to 55 minutes.
14 The mean time to report all scans decreased from 89 to 57 minutes. The survey results were
15 encouraging.

16 **Conclusion** Adherence to NICE guidelines for head injury is inadequate but can be improved by
17 interventions.

18

19 **Key words:**

20 Head injury, Guidelines, Quality improvement, Interventions, CT scans

1 **Introduction**

2 Head injury is a common presentation to the emergency department (ED). In England and Wales, 1.4
3 million people attend ED annually following a head injury (1). Head injury was coded as the primary
4 diagnosis in ED in approximately 400,000 patients in 2014-2015 (3.1% of diagnoses) (2). 95% of
5 patients present with minor head injuries, with a Glasgow Coma Score (GCS) of greater than 12 (1). It
6 is important to differentiate between those who are likely to suffer intracranial complications and
7 those who are fit for discharge, as failure to make this distinction can lead to disability and death.
8 Head injuries account for 9 deaths per 100,000 and 15-20% of all deaths in young males (3). The
9 World Health Organisation predicts that traumatic brain injury (TBI) will be one of the leading causes
10 of worldwide death and disability by 2020 (4).

11 The National Institute for Health and Care Excellence (NICE) have updated guidelines to aid the
12 clinician in the management of TBI in the United Kingdom (UK). In 2004, NICE introduced
13 computed tomography (CT) as the first line investigation for head injuries, replacing skull
14 radiographs. In 2014, updated guidelines introduced clear indications for CT scanning and timeframes
15 (1). These guidelines include an algorithm to follow with a list of risk factors for performing and
16 reporting a CT head scan within one hour or eight hours of the head injury (1). Risk factors include
17 reduced Glasgow Coma Scores (GCS), seizures, focal neurological deficit, skull fractures, multiple
18 episodes of vomiting, warfarin treatment, age, retrograde amnesia, bleeding disorder and mechanism
19 of injury (1). In the United States, The Canadian CT Head Rule (CCHR) and New Orleans Criteria
20 (NOC) are commonly used, with similarities in the clinical decision rules to identify which patients
21 should undergo CT imaging (5).

22 A recent systematic review highlighted that adherence to guidelines for TBI is suboptimal and
23 variable (range 18-100%) (4). It looked at 13 different guidelines that examined the acute treatment of
24 adult patients with TBI, including those from the Brain Trauma Foundation (BTF), NICE, and
25 Scandinavian guidelines (4). It found that adherence was highest for the NICE CT scan guidelines
26 (mean 87%, range 70-100%) and lowest for the BTF Intracranial pressure (ICP) monitoring

1 guidelines (mean 31%, range 18-83%) (4). There was a large between-centre variation, suggesting
2 hospital management and structural characteristics are important in guideline adherence (4).
3 We demonstrate that through simple interventions we can increase local adherence to the NICE CT
4 head guidelines, in terms of requesting scans for appropriate indications and obtaining the imaging
5 and reports in a timely manner. Our interventions have scope to be integrated into different scan-
6 requesting and clerking platforms to further improve management of TBI.

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9 **Aims**

10 This study examines whether the use of CT scans for head injury adheres to NICE guidelines in a
11 large teaching hospital in the United Kingdom (UK). It looks specifically at whether adherence can be
12 improved by simple interventions - namely education, checklists and team engagement.

13 The Royal Free Hospital is part of the Royal Free London National Health Service (NHS) Foundation
14 Trust, one of the largest hospital trusts in the UK, serving 1.6 million people. The trust includes two
15 ED sites and sees over 200,000 attendances annually (6). It is beyond the scope of this study to assess
16 whether adherence improves outcomes and mortality locally, although this has been well documented
17 elsewhere⁴.

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19 **Methods**

20 We carried out a quality improvement project to examine whether the use of CT head scans for head
21 injury adheres to NICE guidelines. The project was formally approved by senior staff of the Royal
22 Free Hospital ED and registered with the trust.

23 To assess the extent of the problem, data was collected retrospectively. All CT head scans performed
24 in the Royal Free Hospital ED over a one-month period (15th January 2014 to 15th February 2014)
25 were examined. Non-head injury CTs were excluded; for example, subarachnoid haemorrhage,
26 psychiatric disturbance or performed as part of a confusion screen. Data was collected from the details

1 given on the imaging request form on Picture Archiving and Communication System (PACS), the
2 patient's notes and PowerChart.(an electronic health record). The clinical indications for the scan, the
3 time to scan, the time to report and patient demographics were recorded.

4 Following analysis of the data, a multidisciplinary forum debated interventions in an attempt to
5 improve the quality of care. This team engagement in itself not only highlighted the issues but may
6 have improved adherence to NICE guidelines through raising awareness.

7 This led to the implementation of three key interventions. First, the results of the data collection were
8 presented at a departmental meeting, educating the multi-disciplinary team regarding the updated
9 guidelines and highlighting current department adherence. 60 clinical members were present at this
10 meeting including doctors and nurses, spanning the range of seniority. Second, a clear head injury
11 pathway was introduced into the ED department. A checklist (sticker) was produced, providing an
12 easy-to-access and clear reference guide for TBI CT head requests based on NICE guidelines (Figure
13 1). Third, teaching sessions on head injury management and the updated guidelines were introduced
14 as part of the induction training of junior doctors. These sessions were held tri-annually for each
15 intake of rotating doctors.

16 The success of these interventions was assessed objectively during a second round of data collection
17 over a further month period (1st May 2017 to 31st May 2017). It was felt that this was an appropriate
18 amount of time later, as it may allow for any initial improvements made through immediate awareness
19 of the problem. Success was assessed subjectively via a survey sent to two groups of junior doctors
20 who rotated through the ED department.

21 The conditions in the department were constant before and after the interventions, including the
22 availability of CT scanners and radiologists. Data was analysed on Microsoft Excel, using simple
23 descriptive statistical tests (percentages, means, ranges) and comparisons using the chi-squared test
24 for categorical variables.

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1 **Results**

2 During the first round of data collection, 199 CT head scans were requested by ED, of which 85
3 fulfilled the inclusion criteria (43% of total). The average age of the patients was 61 years with a
4 range of 23-98 years. Following interventions, in the second round of data collection, 146 CT head
5 scans were requested, 86 for head injuries (59% of total). The average age of patients in cycle 2 was
6 58 years with a range of 1 – 95 years. There was minimal missing data.

7 Figure 2 demonstrates whether the documented indications for CT head requests fulfil the NICE
8 guidelines. A total of 85 scans in cycle 1 and 86 scans in cycle 2 were achieved using NICE criteria
9 for one and eight hours combined. Originally, 30 scans were performed with ‘no clear indication’.
10 This means 35% of scan requests had documented indications outside the NICE guidance. In 2017,
11 only 10 scans (12%) were performed with no clear indication. This is a statistically significant
12 decrease of 23% (95% CI: 10.7-36.5) following intervention (chi-squared test, $p=0.00027$).

13 In 2017 a higher proportion of scans were performed fulfilling the eight hour indication category
14 (51% compared to 32%). This is a statistically significant increase of 19% (95% CI: 3.8-34.0)
15 following intervention (chi-squared test, $p=0.0103$). The breakdown of indications requiring a CT
16 head scan within one hour and eight hours are seen in Table 1 and 2.

17 Table 3 shows the times taken for scans to be performed and reported. The mean time to scan for the
18 one hour indication decreased from 73 to 55 minutes. As for the 8 hour scans, almost all were
19 completed on time in both cycles. The mean time to report all scans decreased from 89 to 57 minutes.
20 Following interventions, there was a percentage increase of 32% in the number of scans being
21 reported within one hour.

22 A survey sent to junior doctors helped evaluate the success of the interventions. When asked to rate
23 the usefulness of the teaching session educating about the NICE guidelines the response was an
24 average of 7.3 out of 10. Following this, 71% used the NICE CT head guidelines when assessing a
25 patient with head injury, whilst the remaining 29% used the information sheet, rather than relying on

1 colleagues or no additional resources. 66% thought the information sheet should be incorporated into
2 the clerking proforma.

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4 **Discussion**

5 The use of CT head scans for head injury was inadequate but was improved through simple
6 interventions. Hospital characteristics, management strategies and local initiatives are key to
7 improving adherence (7).

8 The value of such guidelines lies in improving patient safety, aiding junior doctor or out-of-hours
9 decision making and potentially reducing unnecessary hospital admissions. The guidelines have been
10 shown to have high sensitivity for traumatic intracranial pathology (97.8%) and neurosurgical
11 outcomes or death (100%) if presentation is within 24 hours of injury (8). Specificity was found to be
12 70% and 66.5% respectively (9). In comparison with other national and international guidelines,
13 NICE had the lowest number of patients needed to scan to detect one patient with a pathological CT
14 head finding requiring neurosurgical input (10).

15 Patients are being scanned unnecessarily. However, the number of CT head scans performed for
16 indications not included in the NICE guidelines, and so not based on best practice, reduced following
17 intervention. This is important as CT scans have their disadvantages. One CT head scan in an adult
18 provides the equivalent of one year's worth of background radiation, or 1 in 10,000 lifetime additional
19 risk of fatal cancer per test (11). Financially, the current tariff for performing and reporting a CT
20 head scan is £78, in addition to the cost of extra staff such as porters and radiographers (12). The time
21 cost must also be considered, with an increased likelihood of breaching the four hour ED target.

22 In 2017, there was an increase in the number of CT scans occurring in patients with loss of
23 consciousness or amnesia, plus a clotting or bleeding disorder, including previous bleeds, inherited
24 and acquired disorders. We included novel oral anticoagulants (NOACs) in this category. There is no
25 specific advice in the NICE guidelines regarding NOACs, presumably because in 2014 their use was

1 less widespread. Further clarification is required. Our head injury pathway will be updated further,
2 and will include NOACs as a warfarin equivalent.

3 Following interventions, the time to scan and time to report were reduced, with more cases performed
4 within one hour. This may be due to increased guideline awareness, recognition of clinical
5 indications, and due to systems improvement within the department. Improvement is still needed to
6 reach the NICE targets. Porter waiting time, queues for the CT scanner and patient-specific factors
7 such as management of unstable patients are all likely to have contributed to the delay.

8 Effective triaging and promptly requesting CT head scans can improve the speed at which head
9 injuries are managed. The one hour target set by NICE is measured from the time of scan request to it
10 being performed. This does not include the time the patient spent waiting for clinical assessment and a
11 decision to scan. It is likely that the “door to scan” may be a more appropriate measure than “time to
12 scan.” This is missing in the NICE guidelines. We believe this is important in improving management
13 of TBI, and will include it in our next steps.

14 Most CT head scans were performed within eight hours. 72% of the eight hour scans in cycle 2 were
15 performed within one hour of the request. This is because of the inherent urgency of ED: patients
16 should be seen, assessed, discharged or admitted within four hours. Long waits for CT scanning
17 impacts on patients needing referral and the length of their ED stay. A further study will assess
18 whether inpatients who sustain head injuries are managed as swiftly.

19 As a retrospective study with a relatively small sample size, we recognise its limitations. CT requests
20 require verbal discussion with a radiologist in addition to computer requests, we realise extra
21 information may have been communicated and not documented. It remains unclear whether, in the
22 second cycle, raised awareness of the guidelines improved written documentation and led to more
23 appropriate scan requests, which in the first cycle may have been classed as “no indication” scans.
24 Further review of the individual paper notes will help determine this. In addition, this study has not
25 attempted to address whether improved adherence to guidelines improves local outcomes in head
26 injury, as per the literature (4). We hope to assess this in further studies. In the second cycle, one

1 paediatric patient was included and the clinician had to tailor the checklist according to the NICE
2 guidelines for paediatric patients. We did not exclude this patient from our study as it highlighted the
3 necessity of a similar pathway for the paediatric population, and a second paediatric checklist will be
4 put into operation. This study has been performed at a large teaching hospital in the UK with a patient
5 population likely to be representative of other centres in the developed world. The extent to which
6 these interventions would be relevant in a trauma centre, or less specialised, smaller centres, is yet to
7 be assessed.

8 Finally, this study is limited by its before and after design. It is not known if during the earlier phase
9 there was already a trend towards decreasing time to CT and reporting which continued to the next
10 time of measurement. This is particularly true as the first round of data collection was performed just
11 as the updated NICE criteria were published. Some ED clinicians may not have been aware of this,
12 and others may have been adapting to the implementation of this change. One cannot know for certain
13 whether the improvement observed in 2017 was a result of having the criteria available for a
14 prolonged time or related to the specific education strategies implemented. However, the results of the
15 survey administered to junior doctors suggests a cause and effect relation of the interventions. The
16 teaching sessions were rated 7.3/10 for usefulness, and resulted in 100% use of the NICE CT head
17 guidelines by the junior doctors (71% directly and 29% indirectly via the information sheet).

18 Recent changes in the Royal Free Hospital ED include a new CT scanner and an online CT head
19 ordering system. This system uses checklists and indications to scan are easily identified as per NICE
20 guidelines. The system automatically protocols scans fulfilling the criteria, negating the need to
21 discuss every case with the radiologist and giving them more time to report the scans. A third cycle
22 will assess the impact of these multi-disciplinary developments and we expect increased adherence
23 and improved outcomes for patients with TBI.

24 As hospitals switch to a paperless system, our information checklist can become incorporated into
25 clerking proformas, allowing instant access to key guideline. Moreover, it could aid decision making
26 in triage and initial assessment areas, allowing necessary scans to be performed without the delay in
27 waiting for the clerking doctor.

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1 **Conclusions**

2 Our study shows that by using simple interventions, it is possible to improve local adherence to NICE
3 CT head guidelines. Through teaching and the provision of accessible and easy to use information
4 sheets, we have shown that ED practice can be significantly improved to be more in keeping with
5 official guidelines.

6 The department has recently undergone significant modernisation and we believe that adapting and
7 incorporating our interventions into the new system will bring us closer to achieving our targets.

8 Further studies are needed to assess to what extent clinician judgement plays a role in requesting CT
9 scans of the head for exceptional head injury cases where there is 'no clear indication' as per NICE
10 guidelines.

Declarations of Interest

The authors report no declarations of interest.

Acknowledgements

11 We wish to acknowledge A Bowes, M Kolanko and M Makwana who helped with part of the data
12 collection.

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1 **Tables**

2 *Table 1; Indication for CT head scan within one hour.*

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	Cycle 1		Cycle 2	
	Number of scans (n = 28)	Percentage (%)	Number of scans (n = 32)	Percentage (%)
Post-traumatic seizure	1	4	1	3
GCS <15 at 2h following head injury on assessment in ED	15	54	9	28
Vomiting >1	2	7	11	35
Suspected open or depressed skull fracture	0	0	4	13
Focal neurological deficit	4	14	2	6
Any sign of basal skull fracture	4	14	2	6
GCS <13 on initial assessment in ED	2	7	3	9

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5 *Table 2; Indication for CT head scan within 8 hours. The shaded area represents the patients who experienced loss of consciousness or amnesia as well as the criteria below.*

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	Cycle 1		Cycle 2	
	Number of scans (n = 27)	Percentage (%)	Number of scans (n = 44)	Percentage (%)
Aged 65 years or older	13	48	17	39
More than 30 minutes retrograde amnesia of events immediately before head injury	3	11	4	9
Dangerous mechanism of injury	4	15	0	0
Any history of clotting or bleeding disorders	0	0	18	41
On warfarin	7	26	5	11

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Table 3: Time taken to scan and to report the CT scan of the head.

Time taken to scan						
	Cycle 1			Cycle 2		
	Median (minutes)	Mean (minutes)	Percentage completed in one hour (%)	Median (minutes)	Mean (minutes)	Percentage completed in one hour (%)
One hour scan	48	73	64	36	55	72
Eight hour scan	36	39	100	34	69	98
Time taken to report						
	Median (minutes)	Mean (minutes)	Percentage completed in one hour (%)	Median (minutes)	Mean (minutes)	Percentage completed in one hour (%)
All CT scans	55	89	60	28	57	79

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